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PROJECT:

LANDING LIVE ICELAND SCALLOPS

A Project Managed by the Fisheries Managers (Fiskerisjefene)

in Northern Norway.

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FINAL REPORT

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The report is based on the following interim reports:

1. Report from cruise with "Holmsjö" in the period 23/02-86 - 5/3-86 by P.Eng. Jan L. Hansen, Albatross A/S.
2. Report from visit to Båtsfjord in connection with unloading of "Holmsjö" May 14-15, 1986 by P.Eng. Jan L. Hansen, Albatross A/S.
3. Report on Iceland scallop production at Aarsæther Bros. A/S in Båtsfjord by Inspector Björn Rottem.
4. Report regarding Iceland scallop production at Aarsæther Bros. A/S in Båtsfjord by manager Björn Berg.
5. Report of small scale trials at the Marine Biological Station by researcher Jan Sundet, Prof.Eng. Jan L. Hansen and laboratory head Gjert Fredriksen.
6. Report from cruise with "Nordbas" 9/10 - 3/11 1986, by consultant Steinar Larsen, Barlinghaug Tromsö A/S.
7. Report from cruise with "Nordbas" 23/10 - 4/11 1986, by Inspector Björn Rottem, Båtsfjord.
8. Trip report from study trip to Holland by Steinar Larsen.
9. Trip report from France by Gjert Fredriksen.
10. Trip report from Italy by Jan L. Hansen.
11. Trip report from Iceland by Steinar Larsen

The interim reports can be ordered from the Fisheries Manager, Fiskerisjef, in Troms County.

SUMMARY

The main objective of the project has been to clarify biological and technical limitations on starting an Iceland scallop fishery for delivery to the processing industry ashore.

NOTE: All references to scallops in subsequent sections mean the Iceland scallop Pecten islandicus. (Translator's note).

The results of the project can be summarized as follows:

- Scallops can be stored at considerable heights; 5-6 metres have been tried.
- Flow-through seawater is a better method to store scallops than sprinkling from the top and recirculating the seawater.
- Scallops should be handled carefully and be washed and graded carefully before being stored.
- Scallops can be stored in bulk and be unloaded by pumping. Some shells are broken by pumping.
- Scallops can also be stored in bags; no special equipment is then needed for unloading.
- Scallops can be stored in flowing seawater for up to 15 days before a visible reduction of the quality takes place.
- Even if the scallops were alive, an obvious reduction in quality was noted after 15 days in flowing seawater.
- The muscle from dead scallops has a softer texture and is graded out with the undesirable soft parts in the roller grader.

Based on the observations made and the results obtained in this project it appears to be clear that landing live scallops is a viable alternative. However, it is suggested that trips be limited to 8 fishing days to have a good margin with respect to quality reserves.

1. PREFACE p.2

The research foundation at the University in Tromsö, FORUT, has been responsible for managing the project. FORUT engaged several companies and institutions for carrying out the project. The Norwegian Institute of Fishery Technology Research, FTFI, was involved in the planning of the project and the practical aspects of installing and running the trials at the Marine Biological Station, MBS. Albatross A/S was involved both in planning and in implementation of much of the practical work associated with the trials themselves. The project has had the following advisory board:

Jan Sundet	FORUT
Roger Richardsen	FTFI
Even Tidemann	FTFI
Arne Luther	Fish Inspection,Directorate of Fisheries
Willy Godtlibsen	Norwegian Raw Fish Organization
Sigmund Hågensen	Fisheries Manager's Office in Finnmark
Ragnar Sandbæk	Fisheries Manager's Office in Nordland
Arnljot Arntsen	Fisheries Manager's Office in Nordland
Steinar Larsen	Fisheries Manager's Office in Troms

Mr. Even Tidemann was a member of the advisory board when the project started. He later left FTFI and was succeeded by Roger Richardsen on the board. Ragnar Sandbæk was on the board from the beginning and was later replaced by Arnljot Arntsen. Jan Sundet has been the responsible project leader and Steinar Larsen has been chairman and secretary for the advisory board. Steinar Larsen has left the office of the Fisheries Manager in Troms county and has joined Barlinghaug A/S, but has been involved in the conclusion of the project.

The Fish Inspection Service of the Directorate of (p.3) Fisheries has been involved both on the advisory board and as a participant in the project. They have carried out all their analyses at their laboratory in Tromsö. The head of the laboratory, Gjert Fredriksen, has been responsible for all analyses and the

work done with respect to developing criteria for quality evaluation of Iceland scallops.

Tromsö, 6/11 - 1987

Barlinghaug Tromsö A/S

Steinar Larsen (sign)

2. INTRODUCTION (p.4)

As far the advisory board is aware , there are no projects underway in other countries with the same objectives as this project. Operations in the Faroe Islands and on Iceland are based on catches in near waters where the catch is landed the same day it has been fished. The catch is stored in containers without water on board. After landing the scallops are placed in fresh water to be killed and is then processed the next day. In our waters the vessels will have to travel to grounds at Jan Mayen, Bear Island and Spitzbergen. The catch much be stored alive on board for some period. After being transported to shore, the catch must be unloaded. When catches are large, a part must be held live until it can be processed. As far as the board was aware, none of the various steps of the process had been carried out on a large scale before. The main objective of the project has been to establish the biological and technical limitations on starting to catch scallops for delivery to the fishing industry ashore.

The scallop is a relatively high priced product. It is therefore important to know how scallop handling methods affect product quality. It has been an important part of the project to study changes in quality for different storage methods.

It was not a mandate of the advisory board to look at the investments necessary to start an industry as described. We considered the purse seine fleet as a natural target group for the catching side. These vessels have been built for carrying bulk cargoes. Some of the purse seiners already have installations for circulating chilled seawater in their cargo holds (RSW). The investments will fluctuate depending on the starting point. For example, it can be mentioned that to rig out the purse seiner "Nordbas", which does not have a RSW system, would cost about 1.3 million N.kroner.

The processing of the scallops is not included in the (p.5) mandate of the board either since it is assumed that this is well known from activities in other countries. However, some observations were made during processing at the two plants that

were part of the project, Br. Aarsæther A/S in Båtsfjord and Breivoll Marine Produkter A/S at Breivoll in Ibestad.

3. BACKGROUND INFORMATION ON THE PROJECT

In the summer and fall of 1985 there was suddenly a tremendous interest in scallops. Attention was chiefly focused on the investments that were being made in vessels for onboard processing of Iceland scallops. When the interest in catching scallops increased, the shorebased industry also became interested in the possibility of processing in their plants. The Reginal Investment Board received several applications for financing small and large scallop projects. The applications came from plants and people with interests in catching and processing. Instead of supporting many small projects where reporting of the results is uncertain, the Board decided to support a larger project where the three fisheries managers in Northern Norway were the applicants. This project was planned so that as many as possible of the uncertainties with respect to catching scallops for processing ashore could be addressed.

4. PROJECT DESCRIPTION

4.1 Planning and managing the project

In order to plan the project, a group was appointed that was also to manage the project. The following were members of the planning group:

Sigmund Hågensen	Fisheries Manager's Office in Finnmark
Ragnar Sandbæk	Fisheries Manager's Office in Nordland
Steinar Larsen	Fisheries manager's Office in Troms
Even Tidemann	FTFI
Jan Sundet	IFF, The University in Tromsö
Arne Luther	Inspection Service, Directorate of Fisheries
Kjell Stette	Br.Aarsæther A/S, Aalesund

During the planning of the project it soon became obvious that the information that was available on actual problems was sketchy and in some cases contradictory. We therefore expected to come up against more problems than those we could predict in the beginning. The project was therefore planned so that it was possible to recognize problems early in the study. To simplify management and control of the planning stage the study was organized in four phases that could be run independently of each other.

Phase 1. Small scale trials
Phase 2. Large scale trials.
Phase 3. Market studies.
Phase 4. Utilization of byproducts.

In January 1985 the regional board gave permission to start on stages 1 and 2 of the project. The research foundation at the University in Tromsö, FORUT, was engaged as project managers at startup. Jan Sundet was engaged as project leader. As the (p.8) work progressed there were some changes in the steering group. Even Tidemann left FTFI and was replaced by Roger Richardsen. From October 1, 1986 the first hand sale of scallops was given to the Fishermen's Marketing Organizations. This meant that the Norwegian Raw Fish Organization was given exclusive rights for sales in their

district. The Norwegian Raw Fish Organization was then also included in the steering group for the project and their representative was Willy Godtlibsen.

4.2 Small-scale trials

Since there were so many uncertainties with respect to storage and transport of live scallops, the steering committee concluded that both from technical and economic considerations it was correct to run a small scale trial to simulate the conditions to be encountered on a vessel. The small scale trials were performed at the Marine Biological Station (MBS) in Tromsö. MBS has their own system for pumping in seawater. The most important problems to be studied in planning the small scale trials were:

- will scallops tolerate being piled up high for storage
- how long can live scallops be stored
- what are the effects of storage on quality
- what storage methods are best suited for scallops
- will storage make it more difficult to process the scallops later

An experimental setup was designed from these criteria. For practical reasons it was not possible to try higher storage piles than 2 metres. To evaluate changes in quality, samples were removed at regular intervals and analyzed at the Fish Inspection Service laboratory in Tromsö. The planning group found it interesting to try the following methods for bulk storage of live scallops:

- flow - through seawater
- spraying seawater over the top of the scallops
- recirculating refrigerated seawater (RSW)

For each of these methods the environment was studied and temperatures and oxygen consumption measured. The excretion of waste products, ammonia, in the water was also measured. For more

detailed description of the technical details of the trials we refer to project reports from the small scale trials.

4.3 Large scale trials

The results of the small scale trials were used to plan the large scale trials. The main objective of the large scale trials was to find rational methods for handling the catch onboard and for storage and unloading. To evaluate practical problems in connection with catching, catch handling, storage and unloading of scallops the steering group found it necessary to send a vessel on cruise before the results from the small scale trials were available. The vessel "Holmsjö" M-12-G was chartered in February 1986 for a cruise to take place in the period Feb. 23 - March 5. During this cruise many practical problems were encountered that had not been predicted in the planning stage. The largest problem occurred in the attempts to unload scallops with a pump. In the month of May , "Holmsjö" was on a regular fishing trip to Jan Mayen. The catch was delivered in Båtsfjord and unloaded by pump. A representative of the project group was present to observe the results. Later in the fall, after the scallops had recovered after spawning, a cruise was carried out on the M/V "Nordbas". The first cruise was carried out in the period Oct.9 - Oct.22. and the second between Oct. 23 and Nov. 3. The most important questions to be answered in these cruises were:

- will the scallops survive the handling they are subjected to during catching, washing/cleaning and sorting (p.10)
- will the scallops tolerate storage and transport over long periods and under the conditions found onboard a purse seine vessel
- in how deep piles can the scallops be stored
- how much shell damage can scallops tolerate before they die
- testing of different methods for storage, for example bulk storage and storage in bags
- testing of different methods for unloading scallops
- monitoring environmental parameters that can be indicators for developments in the cargo
- to monitor quality developments

On the cruise with "Holmsjö" a number of problems were identified and methods for solving them proposed. On the cruise with "Nordbas" later in the fall various problem solutions were tried.

4.4 Market studies

While the resource base will be decisive for how large the scallop industry will become, the marketplace will decide if the products can be sold at profitable prices. Both the private and the public sectors will be affected if an industry is built without a market base. The steering committee therefore thought it would be important to initiate a market study in parallel with the development work that is the objective if the project. The market study was organized as a separate project for practical reasons and was carried out by The Institute of Fishery Technology Research (FTFI). A separate steering committee was appointed for the market study. The project consists of two research person years and is financed by:

The District Development Fund (DU)	kr. 400,000	(p.11)
The Sector Council (LU)	" 400,000	
Efficiency improvement funds	" 191,000	
Total cost	kr. 991,000	

The project was financed in September 1986 and started shortly afterwards. It will be completed in 1987/88. The project is so organized that interim reports will be available as the work is progressing. These will be available at the Fisheries Manager in Troms. When the market study is completed, a separate report will be issued.

4.5 Utilization of byproducts

In the production of scallops there will be a relatively large quantity of byproducts in the form of shells and the soft parts separated in the processing step. Therefore, a study should be done of possible uses for these byproducts. No action has yet been

taken on this part of the project for several reasons. The main reason is that the steering group would like to complete the first part of the project and then look at byproducts when a land based industry has been established. There has also been certain problems with getting catches for this project . Reference is made to Sect.8.

4.6 Financing of the project

Financing:	
The Sector Council (LU)	kr. 2,750,000
Norwegian Raw Fish Organization	" 300,000
Total budget	kr. 3,050,000

The Sector Council (Landsdelsutvalget) showed great cooperation and flexibility in the financing of the project. Due to the uncertainty inherent in the planning of the project, we were first allocated kr. 1,500,000. As the project became better defined, the rest of the funds were made available. When the Norwegian Raw Fish Organization was given a monopoly on the first-hand sale of the scallops , it was represented on the steering committee and also participated in the financing of the project.

5. RESULTS

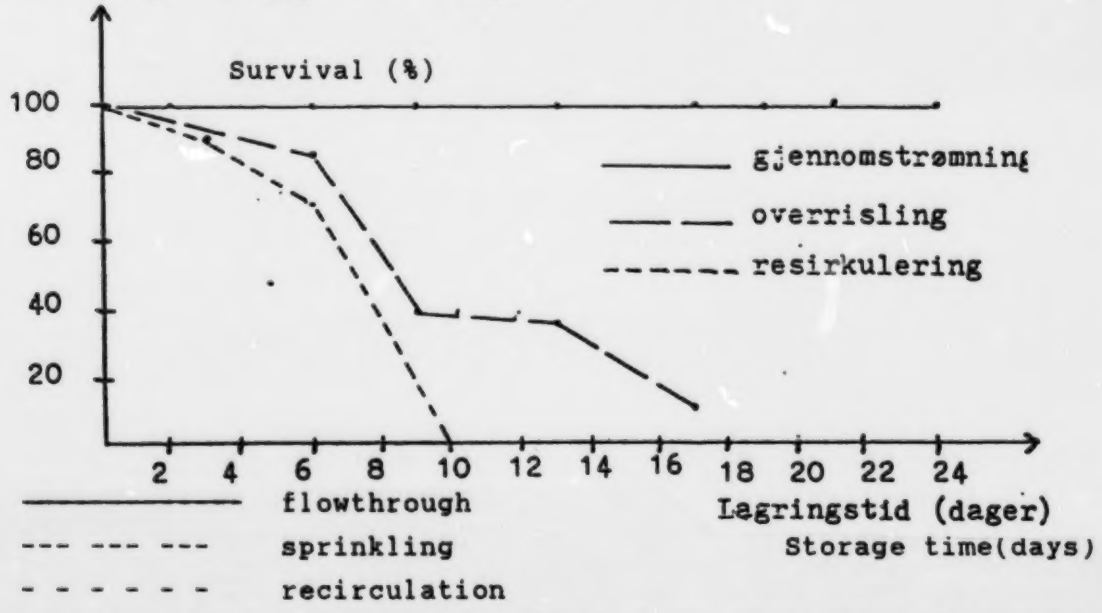
5.1 Small scale trials

The results from the small scale trials are discussed in detail in the interim report of this part of the project. Here the results will be presented in a more concentrated form without too many details.

5.1.1 Survival

Samples were taken regularly in the various trials and the mortalities registered.

Fig 1. Survival of scallops for three methods of bulk storage. The trials with flow-through and sprinkling were carried out in parallel in the period March 12-April 4. The RSW trials were done in the period Sept. 19 - Sept. 29.



The live storage method used will be of great importance for the vessels. For throughflow of seawater the vessel must carry large quantities of water. This has consequences for steaming time

and fuel costs. If sprinkling is used, a much smaller load must be carried. In the RSW method the temperature will be constant during the whole transport. The scallops will thereby not be subjected to the temperature increase that otherwise occurs when the vessels come from cold Arctic water to temperate water near the coast. For flow-through seawater there were no mortalities in the storage period. After 24 days the scallops were still alive. For the sprinkling method the survival was good in the beginning of the period. After 6 days the scallops started to die and 80-90% had died after 10-12 days. For RSW storage there was good survival in the beginning of the period. After 5-6 days there is a sharp increase in the mortality. After 10 days all the scallops were dead.

The results show clearly that flow-through seawater is the best method to store scallops. Storage using the sprinkling method has definite limitations; the scallops started to die after 5 to 6 days and the mortality increases quickly. It is difficult to make firm conclusions from the RSW-trials performed. This is associated with the fact that the compressor used to oxygenate the water did not operate as planned. The oxygen content in the water therefore decreased from ca 7 ml/l the first day to ca 2.5 ml/l on the fourth day. The oxygen content then increased somewhat again, but after ten days the oxygen content was reduced to zero. The only valid statement that can be made about the RSW method is therefore that the scallops were doing fine in the first few days. As the oxygen content declined the mortality increased and was total when the oxygen was used up. Nothing definite can therefore be concluded about RSW storage of live scallops from these trials. Based on biological and technical considerations, it is still (p.15) believed that flow-through seawater combined with RSW would be a good alternative for storage and transport of live scallops. Flowing seawater can be used until the vessel reaches temperate coastal waters. It would likely also be necessary to use RSW when the vessel enters polluted harbor basins.

5.1.2 Environmental monitoring

5.1.2.1 Water flow-through

In sprinkling and flow-through trials the water flow was ca 50 l/min. This corresponds to a complete change of water 3-4 times per hour. For RSW storage the flow-through was 70 l/min.

5.1.2.2 Oxygen, temperature and salinity

In sprinkling and flow-through trials the oxygen content in the water on the intake side was 7-8 ml/l. At the outlet the oxygen content was 6-7 ml/l. The temperature was 2.2 - 3.8 degrees C in the period. The salinity was $34.5^{0}/_{00}$ in the beginning of the period and later decreased to ca $33^{0}/_{00}$. This reduction is small and not unusual in the natural environment.

During the RSW experiment the temperature varied from -0.8 to 2.6 degrees C. The salinity was constant at ca 34.5 $^{0}/_{00}$. The oxygen content at startup was 7 ml/l and declined to ca 2.5 ml/l after 4 days. From the fourth day the oxygen content increased slightly and then dropped to zero after 10 days. The adverse variations in the oxygen content were due to the fact that the compressor that should supply air to the system did not operate as planned.

5.1.3 Quality (p.16)

5.1.3.1 Sensorial analyses

Table 1. Sensorial analyses of samples from trials with flow-through seawater. The values are relative (percent).

			sensorisk analyse			
			lukt odor			
days døgn	live levende	dead døde	normal	off avvik	spoiled bedervet	appearance utseende/ konsistens texture
3	100	0	100	0	0	normal
6	100	0	100	0	0	"
9	100	0	100	0	0	"
13	100	0	95	5	0	"
16	100	0	51	49	0	bløtere/mørkere softer/darker
19	100	0	39	61	0	"
23	100	0	11	89	0	"

There were no mortalities in flow-through seawater. Even so, the sensorial analyses show that after 13 days there is a change in the odor even if appearance and texture is normal. After 16 days, a change in appearance and texture occurs. This means that under the conditions given the storage limit is less than 16 days.

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(p.17)

Table 2. Sensorial analyses of samples from trials with sprinkling of seawater. The values are relative (percent).

			sensorisk analyse			
			lukt odor			appearance utsende/
days døgn	live levende	dead døde	normal	off avvik	spoiled bedervet	konsistens texture
3	100	0	100	0	0	normal
6	92	8	61	39	0	"
9	44	56	44	56	0	"
12	38	62	5	24	71	bløtere/mørkere
16	12	88	5	50	45	softer/darker

After 6 days there was a certain mortality that increased rapidly. At the same time there was a change in the odor of the samples. Appearance and texture were normal after 9 days in spite of increasing mortality and changes in odor. As the mortality increases, decomposition is rapid. After 12 days there was spoilage odors from 71% of the samples.

For both samples it was found that there could be odor changes even if appearance and texture were normal. It should especially be noted that there were changes in odor and appearance in scallops stored in flowing seawater. All scallops that were taken as samples from this trial were alive when taken out. There has therefore been a quality reduction in living scallops involving changes in odor, appearance and texture. No sensorial analyses from the RSW trials have been included here. This is connected with the problems discussed in Sect. 5.1.1.

5.1.3.2 Biochemical analyses

Samples from the trial were analyzed for TMAO-N, total

volatile nitrogen (TVN) and TMA-N. The objective of these analyses was to find out if these methods can be used for this type of raw material, and further, to see if there is a relationship between the sensorial and the biochemical analyses.

The analyses from the trials with flow-through seawater show a fairly constant level of all the three parameters. The values fluctuate slightly around an average value. The fluctuations observed show no correlation with the changes shown in Table 1, sensorial analyses. For further discussion of the biochemical analyses we refer to the interim report from small scale trials.

5.2 Large scale trials

To study problems in connection with the large scale trials, the 175 ft purse seine vessel "Holmsjö" was chartered for a cruise in the period Feb.23 -March 5 to the grounds off Troms. The most serious practical problem during this cruise was that the conveyor belts on deck froze. There were further difficulties in that the speeds of the belts were not coordinated. There were therefore pileups of scallops at certain points. "Holmsjö" delivered the catch to Aarsæther Brothers Ltd. in Båtsfjord. Before the project was initiated, it was guaranteed that the fish pump in Båtsfjord could pump scallops. However, it soon became obvious that unloading was going to be a very difficult problem to solve. After the small scale trials were completed, another vessel ,"Nordbas", was chartered in September for two cruises to the grounds off Bear Island and Spitsbergen. During these cruises the problems around pumping live scallops were solved.

5.2.1 Gear

5.2.1.1 Catching ability

Both "Holmsjö" and "Nordbas" used scallop rakes manufactured in Iceland. Along the coast where dragging was carried out at depths of 30-60 metres these rakes functioned well. North in the Barents Sea where fishing was carried out at depths of 90 - 110 metres the rakes were less efficient. "Nordbas" had catches per day of up to 9000 kilos. Other vessels on the grounds used American rakes and had better results. However,it is difficult to quantify the differences in catching ability between these rakes.

5.2.1.2 Handling

"Holmsjö" had the bin for dumping the catch aft of the deck house while "Nordbas" emptied the rakes on the foredeck. Both vessels set and hauled the rakes on the starboard side by using an unloading boom/crane where the rake was hanging loose while working. To operate the rake this way is a poor solution both because many scallops are crushed when the rake hits against the side of the vessel and because it can be dangerous for the crew with the rake hanging loose when the vessel is rolling. The rake should be hauled over the stern where it can be hauled and set while mounted on a "sled". The rake can then be operated without danger of crushing the catch and without danger for the crew.

5.2.2 Handling and storing the catch onboard

Both vessels are purse seine vessels that had rigged the receiving bin and the washing/cleaning drum on the shelterdeck. This means that the crew is exposed while working in poor weather. The conveyor belts froze in periods with very cold weather. It must also be taken into account that the cold will affect the survival of live scallops. To expose the scallops to very cold weather can therefore lead to increased mortality in later storage. In future operations where scallops are to be stored alive for transport to shore, washing and cleaning of the scallops should therefore be

carried out below the shelterdeck. If the scallops have to be stored for shorter or longer time on the shelterdeck they should be held in seawater, when it is very cold.

5.2.2.1 Bulk storage

Bulk storage means that the scallops go directly from being washed and cleaned into the hold which has been filled with seawater. This results in simple and rational handling of the catch. During fishing operations , 2-3 men were working on deck. Bulk storage of the catch presumes that unloading can be carried out by pumping the scallops ashore. In the trials carried out, scallops were held in heights up to 6 metres.

5.2.2.2 Storage in bags

Unloading with a pump became very problematic during the first cruise with "Holmsjö". In order to have an alternative to bulk storage, bags were made of trawl twine for storage of the catch. This form of storage was more labor intensive for the deck crew. The bags were hanging from the hatch for filling with scallops. The bags must then be closed and lowered into the hold. Storage (P.21) in bags requires more labor during fishing operations, but in contrast it does not require any special equipment during unloading. The size of the bags was 1 m^3. This appeared to be a suitable size to work with. However, it could well be imagined that another size could be used if it suits the individual vessels better.

5.2.3 Unloading of the catch

5.2.3.1 Unloading by pump

Unloading was not considered to be a problem during the planning stage of the project since we were assure that to pump scallops was simple. However, during the first cruise with "Holmsjö" when the catch was taken to Aarsæther Brothers Ltd. in

Båtsfjord, unloading became an unsolvable problem. The pump in Båtsfjord ("Fish Quick" rapid unloader type R630) that was being used on pollock and cod did not function on scallops. The reason was that the pump was equipped with flap valves that opened and closed as the pump alternated between pressure and vacuum. The scallops got caught in the valves and the pump did not work. After repeated trials the scallops had to unloaded with a grab.

When "Holmsjö" in May came from the cruise to Jan Mayen, the steering group sent a representative to Båtsfjord to observe the unloading. Another model of the same make of pump had been made available ("Fish Quick" rapid unloader Model R801). The same pump was moved to Breivoll in Ibestad when "Nordbas" was on cruise in october. For further description of the pump we refer to the report from the cruise with "Nordbas".

Seen in isolation, the pump appeared to work well. (p.22) However, there were problems in maintaining continuity during unloading. There were problems in guiding the suction hose in the hold because the water was cloudy and the hose was difficult to handle by hand. If the suction pipe socket came too close to the pile of scallops, too many scallops entered the hose and plugged it. This can be avoided by mounting a guard on the pipe so that it does not come too close to the scallop pile. Another problem was to maintain the water level in the hold.

The pump water must be returned and this could be problematic due to the large quantity of water. Furthermore, the pump had problems with the lifting height at low tide. Lifting heights up to 5.5 - 6 metres could be handled, but at 7 metres there were problems with plugging up both on the suction side and the pressure side. If continuity in pumping can be maintained, it should be possible to unload 25 - 30 tonnes per hour.

5.2.3.2 Unloading containers ashore

When "Holmsjö" came to Båtsfjord the first time to unload scallops, no special provisions had been made ashore for landing the scallops. The scallops were pumped into a container used to drain water from capelin and pollock. The container was designed so that the water drained off and the fish slid into another container for further transport. This solution did not function for scallops. Scallops do not slide like fish. In the drainage container the scallops were subjected to blows and breakage. It was also difficult to lead the pump water back to the hold.In order for pump unloading to be a viable alternative, the scallops must be handled as gently as possible. To meet these requirements a special unloading container was constructed where the scallops are transported in water. This container was tested in the (p.23) unloading of "Nordbas" in October and worked as designed. From the unloading container the scallops are led on a conveyor to smaller containers for processing or storage. For description of the unloading container we refer to the report from the cruise with "Nordbas".

5.2.3.3 Unloading of bags

In order to have an alternative to bulk storage and pump unloading , a trial was made with storage of scallops in bags. Bulk storage presumes that the buyer has a pump for unloading the catch. If the scallops are stored in bags, no special equipment is needed for unloading. Unloading can be done with a crane. Ashore the bags must be emptied over into smaller containers for transport. The capacity for unloading bags will be dependent of the size of the bags and how the reception is arranged ashore. The experience from the experiments made was that the unloading of bags is simple and uncomplicated; it is easy to maintain continuity in the work. The capacity is still limited and less than with pump unloading when this is carried out without too many problems. When "Holmsjö" unloaded in Båtsfjord in May the bags weighed on average 245 kg. The capacity was then ca 6 tonnes /hr.

5.2.4 Intermediate storage ashore

The capacity of a processing line is ca 20-25 tonnes per shift. When large catches are being landed it would be necessary to store some of the catch until it can be processed. Scallops must be stored alive. The storage trials made in the small scale trials show which storage times can be acceptable for scallops.

However, the handling that the scallops are subjected (p.24) to during catch, in storage during transport and during unloading must be a stress that also affects the condition of the scallops. To test this effect, a storage experiment was carried out in Båtsfjord in March. When "HolmsjÖ" arrived in Båtsfjord the scallops were 4-5 days old. Some scallops were placed in storage with flow-through seawater and seawater sprinkling. The scallops held in sprinkling seawater started to die in 3-4 days. The scallops held in flowing seawater were alive after 7 days. For both storage methods the mortalities came suddenly and in a few hours all the scallops were dead. No sensorial analyses of the scallops were made during these storage trials. It should be added that these scallops were unloaded by pump into a drainage container for fish where they were subjected to blows before they were transferred to a container for intermediate storage. Even so, the scallops kept in flowing seawater were alive after 7 days, a total of 11 days from the catch date.

5.2.5 Environmental monitoring

In the storage of live scallops, it is important with an exact monitoring of the environment. The environmental parameters that must be monitored are oxygen, temperature and ammonium. Normally the oxygen content in seawater is sufficient, but during RSW storage the oxygen content could come down towards critical levels. The temperature is often given when water is pumped through the cargo. But it is here important to realize that large and rapid variations in the temperature can be very stressing for living organisms and scallops are no exception. When a vessel comes from Arctic waters and into the coastal current the temperature can

change very quickly.

Nitrogen is a metabolic product that is toxic to (p.25) marine organisms. In seawater most will occur as ammonium. Ammonium is therefore an indicator that the condition of the environment is worsening. This can be counteracted with a sufficient flow of seawater. How large this flow must be is dependent on how many scallops are stored in the tank. It is also dependent on the temperature in the tank. It is difficult to give concrete recommendations, but from the results obtained in the trials the flow should be high enough to exchange the tank volume once per hour. It is assumed that the water distribution is even throughout the tank.

5.2.6 Quality

During the cruise with "Nordbas" in October samples were taken of the catch from different days. The samples were subjected to sensorial and biochemical analyses. The analyses showed clearly that damaged scallops deteriorate faster than undamaged animals. Whole and undamaged scallops were of good quality after 8 days storage in the hold, while shells that had been damaged when placed in storage had reduced quality already after 3-4 days. For a more detailed discussion of the analyses we refer to the interim report from cruise with "Nordbas" in October 1986.

5.3 Measurements made during fishing operations

Commercial activities based on the Iceland scallop are new and when the project started, little was known about requirements for storage and processing. Some simple trials were therefore made to come up with some basic data.

5.3.1 Stowage factor

In the transport of live scallops it is an advantage to know how many scallops could be stored in a certain hold. Measurements on scallops caught inshore showed a stowage factor of ca 0.5. This means that one cubic metre of whole scallops would weigh ca 500 kg.

In actual practice the stowage factor would be lower since the scallops are not distributed evenly in the hold. Under the hatch the scallops would be in a pile. They do not slide sideways in the hold like fish. Inshore the scallops do not have much growth on them. Scallops from the Barents Sea will take up more space since they are covered with barnacles and other growth.

5.3.2 Yield measurements

The yield in the processing of scallops fluctuates throughout the year and can also vary depending on how much growth is covering the shells. When the Norwegian Raw Fish Organization received a monopoly on the first-hand sale of scallops, an important job was to find a system for setting prices that would take into consideration the variation in yield. In that connection it was necessary to make yield measurements on scallops.

The measurements were made by processing a number of scallops by hand. The measurements were repeated a number of times on scallops from different locations and of different sizes. Measurements were made on whole, undamaged scallops and on scallops damaged on loading. Repeated measurements on undamaged scallops gave a yield of 10-15 %. The variation in yield is due to several factors. The single factor that had the greatest effect was the degree of growth of barnacles etc. on the shells. Measurements made on scallops from Bear Island in October gave a yield for hand processing of 12.1 -14.07 %; average 13.35 %. For machine processing on undamaged scallops the yield was 10.95 %. Machine processing of damaged scallops resulted in a yield that was 3.5 - 4 % lower.

6. FIRST HAND SALE OF SCALLOPS (p.27)

From October 1, 1986 the first-hand sale of scallops was given to the fishermen's marketing organizations. The Norwegian Raw Fish Organization (Norges Råfisklag) was thereby given a monopoly on marketing of scallops in their district. The experiences made in this district have formed the basis for the regulations established for the sale of scallops. The regulations are divided into three parts:

6.1 Onboard processing on large scallop processing vessels

It is possible to establish firm supply agreements between the producer and/or owner and the buyer. This is a temporary arrangement.

6.2 Processing of catches from smaller vessels

Those fishermen that earlier had carried out manual processing onboard and sold the products in frozen form to domestic or foreign buyers can apply to receive conditional permission to market their own catch. Self-processed catch that is marketed fresh, iced or in brine shall be delivered to approved buyers. Minimum prices have been set for self-processed catches.

6.3 Landing of live scallops for processing ashore

A sample of minimum 1% of the catch shall be taken out as a representative selection for control weighing. The catch is sorted in whole scallops, damaged scallops and empty shells, rocks and other discards. The various parts are weighed after the water has been drained off. The minimum price is related to the yield. The yield for machine processing is for now set 3% lower than the yield for hand processing. The price for damaged scallops can be permitted to be reduced by up to 30%.

For further information on the rules for first hand sales we refer to Circular NO. 75/86 issued by the Norwegian Raw Fish Marketing Organization.

7. STUDY TRIPS (p.28)

Commercial activities based on scallops are rather new in Norway while in Southern Europe there has been a scallop industry since early in the last century. While planning the project a study trip with the following objectives was carried out:

- to look at various forms of adjusting exploitation to the resource base
- to look at various types of processing gear
- to see how catches are regulated
- to see how the quality control was organized

The trip took place in Holland, France, Italy and Iceland.

In Holland the equipment manufacturer Franken BV was visited. This company produces processing equipment for the shellfish industry. Most of the equipment was designed for the processing of mussels and related species.

In France the delegation visited ISTPM - Institute Scientific et Technique des Peches Maritimes who is responsible for monitoring the sanitary standard in the areas where scallop processing is carried out and also the quality control of the finished products.

In Italy an equipment manufacturer, Dareccio, who produces equipment for the food industry was visited. They also produce equipment for the production of clams, mussels and scallops.

In Iceland we went to Stykkisholmur in Breidafjordur (p.29) where we were out on a vessel and observed fishing operations. We visited a processing plant, Torsnes A/S, and an equipment manufacturer, Skipavik A/S. In Reykjavik we visited the Marine Sciences Institute, the Fish Inspection Laboratory and the Icelandic Freezing Plant Corporation.

For more details from the study trips we refer to interim reports from these trips.

8. ESTABLISHMENT OF AN INDUSTRY BASED ON THE PROJECT WORK

Initially anyone could set themselves up in business based on scallops. In Troms county there has for some years been a limited processing of scallops caught on the grounds in the fjords of Troms. Otherwise there has not been any activity before the first scallop factory vessels arrived on the scene in 1985. Two processing plants for scallops were established in 1985/1986, one in Båtsfjord in Finnmark and one in Ibestad in Troms. These plants were based on the premise that raw material should be supplied from the grounds in the Barents Sea.

For the transport of live scallops a vessel must be built for carrying cargo in bulk. The purse seine fleet was therefore a natural goal for the project. Both vessels that have been engaged in the project are purse seine vessels. However, there has been little interest shown by this fleet to get involved in the activities promoted by this project.

In the winter of 1985/86, a large number of companies applied for licenses to process scallops onboard factory vessels. The knowledge of the resources was at that time very limited. The Ministry of Fisheries decided to limit the number of vessels until more information on the resource was available. This was done by royal Decree of February 14, 1986 and later J-Notice 27/87 - Regulation on Registration Prohibition for Vessels to be used for Scallop Dragging. This regulation is so formulated that it is forbidden to register vessels over 250 gross registered tons and the prohibition applies to and including December 31, 1987. To be profitable, a vessel for catching and transporting live scallops must be able to carry 200-300 tonnes. This corresponds to a volume of 700-800 cubic metres. Such a vessel will be above the limit set for registering vessels for scallop fishing. (p.31)

In 1987 there was a concrete project for establishing an industry as stated in the objectives of this study. However, the vessel was more than 250 GRT and the project had to be put on hold. The Ministry of Fisheries was informed about this, but as far as we know nothing has been done to change the conditions.

The status is therefore that the Fisheries managers in Northern Norway started a development project in January 1986 financed from public funds. Both the Ministry of Fisheries and the Directorate of Fisheries have been informed about the project and its objectives. One month later the Ministry of Fisheries issues regulations banning the establishment of the type of industry described in the project objectives.

9. DISCUSSION (p.32)

The main objective for the project was to clarify some of the problems inherent in connection with storage and transport of scallops under such conditions and over a period long enough to establish a profitable operation. The catch shall be used for human consumption and it is therefore important that the quality is satisfactory.

The storage experiments done at the Marine Biological Station indicated that seawater flowing through the scallops is the best method for transporting scallops. Sprinkling and circulation of refrigerated seawater (RSW) is an alternative for short-term storage, i.e. storage up to 5-6 days. For storage in refrigerated seawater the storage time will be dependent on several factors where filtration capacity is one of the most important. A combination of flowing seawater and RSW could be used in periods of the year when the water temperatures in the coastal current and in the fjords are high. From the trials done it is difficult to say anything about water requirements for scallops stored under conditions as those described here.However, it can be said that if the water volume in the hold is changed once per hour it should be safe. The degree of exchange should depend on how much cargo is in the hold.

The equipment used today for handling the catch onboard gives the scallops a very rough treatment. The scallops are dropped into a funnel where they are subjected to blows. They then go through a cleaning and washing drum where they are washed with high pressure

water and where other undesirable materials are separated. In the first part of the process, i.e. in the rake and receiving bin, about 25% of the scallops are broken. In the washing drum a further 14% are broken. For live storage the damaged scallops should (p.33) be segregated since they lose quality sooner than undamaged scallops. The washing drum cleaned the shells well. It is important that the scallops are cleaned of sand and mud before storage. If sand and clay accompany the scallops into the hold, it will collect on the bottom and suffocate the bottom layers of scallops. When scallops are to be stored alive, it is important that they are not subjected to rough treatment and unnecessary blows. If it is necessary to drop scallops from a given level to another, it should be arranged so that they will land in water.

Storage of scallops in bags and bulk storage are alternative methods for catch storage. Storage in bags and later unloading result in a very gentle treatment of the scallops and there are no special requirements for unloading. Bulk storage requires special equipment for unloading. The pump used for unloading ("Fish Quick" rapid unloader, model R801) worked well. To give the scallops a gentle treatment, there should also be a specially constructed unloading container on the pressure side of the pump so that the scallops are always transported in water. In the pump-unloading of scallops from the Barents Sea, which are often covered with growths, barnacles etc., a considerable number of the scallops were damaged. The number of scallops damaged in the unloading of bags was 16%, the same as when dropping the scallops into the hold. The number of damaged scallops when pumped was 39%. For scallops caught near the coast, which have much less growth on the shell surface, the damage percentage was much lower. If scallops caught in the Barents Sea are to be stored again before being processed ashore, they should be stored in bags. If they are to be processed directly, they can be stored in bulk and be pumped ashore.

An important assumption for starting to fish and transport scallops to shore is that the handling and transport the scallops are subjected to does not result in reduced quality for the end

product. In the storage trials carried out at the Marine biological Station and later on the cruise with "Nordbas", samples of the catch were therefore inspected for quality developments. The trials at MBS showed that flow-through seawater is the best method to preserve the quality. Scallops damaged before storage lose quality much faster than undamaged animals. An important observation was that the quality was reduced during storage even if the scallops were alive. In the storage trials with flow-through seawater , all the scallops were alive after 24 days, but there was a different odor from the samples and the muscle became softer and darker in color. Analyses of the nutritional content indicated a reduction in dry matter and protein after long-term storage.

In the storage and transport of live scallops some of the scallops will die. In the later processing it could be difficult to segregate these scallops. Muscles from dead scallops could therefore be mixed in with those from live animals. In processing trials at Breivoll Products A/S in connection with unloading of "Nordbas", muscle from live scallops and muscle from dead scallops were passed through the roller machine at the same time. It turned out that poor quality muscles with a softer texture were pulled through the rollers and discarded together with the waste.

In our waters scallops spawn in June/July. Close to spawning time the scallops are very sensitive to handling. In Iceland the fishery is stopped in February/March and started again in August when the scallops have recovered from spawning. The same is found in other countries where scallops are caught from wild stocks; during the spawning period the animals are left alone.

The results from the trials carried out show that landing of live scallops is a possible alternative. The organization of the work onboard must be changed so that the scallops are treated more gently. The activity would be seasonal with a pause for 3-4 months when the scallops are spawning. Scallops can tolerate storage for 15 days before a visible deterioration of quality takes place. If the fishing trips are limited to 8 days, there is a reasonably good margin for quality reserve in the scallops.